DPD 2539-61
COPY / OF

OXC 1590
COPY 2 OF 2

14 April 1961

Mr. R. M. Bissell
L Building
17th and Constitution Avenue
Washington D. C.

Dear Mr. Bissell:

Hycon Mfg. Company is pleased to present this proposal for a high altitude photo reconnaissance system in accordance with your request to Mr. Trevor Gardner.

This proposal is based upon the technical report entitled "High Altitude Reconnaissance System Study" furnished under Contract Number AF 33(600)-42034, and upon Hycon's proposal for the E-6 photographic system for Samos. These documents are to be considered a part of this proposal.

Hycon proposes a two phase program - Phase I to consist of the fabrication and delivery of one prototype HR 244 camera system according to the enclosed specification entitled "Recommended Specification Camera System Aerial Reconnaissance High Acuity 18 x 18 Inch Format Type HR-244".

Phase II will consist of fabrication and delivery of ten (10) production systems HR-244.

STATINTL STATINTL

Phase I can be accomplished for a total price of [redacted] and Phase II can be accomplished for a total selling price of [redacted]. These prices reflect the fact that a large portion of the basic design has already been accomplished in the 73B and 73C camera systems.

STATINTL

Should additional information be required, please contact [redacted] Engineering.

STATINTL

Very truly yours,

STATINTL

[redacted]

KEH:fb

Enc.

ORGANIZATION

The organization of Hycon is such that a program such as is proposed can be accomplished with complete control and dispatch yet without unauthorized personnel even being aware of the program. (See Figure 1)

The HR-244 program will be done completely with the Engineering Division except for detail piece parts which, in themselves, are nonrevealing.

Virtually all of the key personnel responsible for the design and manufacture of the A-1, A-2 and 73B camera systems will be available either for assignment to the HR-244 program or for consultation as needed.

The Special Equipment Department (see Figure 2) is organizaed as a separate function for use on Special Project Contracts only and, as such, is prepared to service the proposed program.

The production organization within the Special Equipment Group is composed of the key personnel who fabricated the original special equipment. These personnel will be used to the fullest extent in the HR-244 program. The machinery and equipment acquired by Hycon for use in the Special Equipment Program is still in first class condition and can be set up for use on this program as necessary.

CONTRACT ADMINISTRATION AND ACCOUNTING

Contract Administration of all Special Project Contracts has been separately handled in the Special Equipment Department since 1955. This procedure would be continued in the proposed program.

Hycon has an accounting system which is approved by the U. S. Navy Audit Service for use with government C. P. F. F. type contracts. The accounting system is maintained in accordance with procedures issued by the various military departments facilitating ease of audit and cost control.

In December 1961, Hycon's cost accounting will be centered around a new National Cash Register Electronic Data Processor. In addition to cost control, this new computer will be used to control inventories and to greatly reduce the routine planning efforts in Production Control and Engineering.

Next 1 Page(s) In Document Exempt

SECURITY

Hycon is well aware of the security requirements and procedures of the Special Project. The Special Equipment Department was set up in 1955 as a separate group in order to maintain these special security requirements. Hycon personnel have worked in close cooperation with the security personnel for the past six years, and our performance in this area has been characterized by them as completely satisfactory.

The key personnel in management and the camera design engineers have current Iealist authorizations. Thus, the proposed program could be initiated immediately without causing extra burden on the security personnel for processing of new authorizations and clearances.

The main Hycon facility in Monrovia (see Facilities, Figure 3) has ten engineering laboratories, three of which could be made immediately available for exclusive use of the HR-244 design group. Assembly drawings and final assembly can be maintained in the Special Equipment facility or in the available space in the Hycon Monrovia plant.

ASSOCIATED PROJECTS

Application to the HR-244 program of advanced technology from related programs will be abundant.

In addition to the experience gained through the design and manufacture of many advanced camera systems, including the A-1, A-2 and 73B Configuration, the technology of current Hycon programs will be available.

Hycon was selected by the West German Air Ministry to design and manufacture Aerial reconnaissance equipment for the F-104G. This program entails the design of a new 36" folded optics system similar in principal to the 73B Configuration as well as other ancilliary cameras.

Hycon has been awarded a contract by the U.S.A.F. for the design and manufacture of camera systems for the U.S.A.F. X-15 high altitude research program. New data on high altitude phenomena including boundary layer and thermal, will be forthcoming from this program in time to be used to advantage on the HR-244 program.

FIELD SUPPORT

Field support of the camera systems, after delivery, will require the same high quality as of the system itself.

The building of a high grade field organization, which has the capability of operating and maintaining high precision optical equipment, is no small task. Coupled together with the requirement for high grade personnel is the requirement that these personnel must be ready at a moment's notice to deploy to any point in the world for practically any length of time.

The requirements that a field engineer must meet to join such a group are rigid. Hycon uses rigorous selection procedures to obtain qualified men willing to accept the personal inconvenience required. After selection, intensive training in the plant and on the job training in the field, further selection permits only the most qualified men to join the operational group.

Hycon, under contract with the Special Project, has, over the past five years, put together such a field service organization. This organization is built around a solid core of hard working, skilled and dedicated field engineers who will be available and willing to support the HR-244 camera system whereever and whenever necessary.

LENS DESIGN AND MANUFACTURE

Since a camera system can be no better than its lens, Hycon has continued for a number of years to survey the available lens designers and manufacturers.

[redacted]

STATINTL

HR-24 CAMERA

The discussion below is presented in order to amplify the data contained in the referenced study report. Those areas which are covered in detail in that report are not repeated here.

CAMERA DESIGN COMPARISON

Lens type	Refractor	Refractor
Focal length	36"	48"
Relative aperture	f/10	f/5.6
Half angle	14 degrees	10.5 degrees
Format	18" x 18"	18" x 18"
Angular resolution	23×10^{-6} radians	8×10^{-6} radians
Ground resolution	w 1.5 feet at vertical (70,000 feet)	w 0.49 feet at vertical (120,000 feet)
System resolution on axis	55 l/mm low contrast	110 l/mm low contrast
System resolution AWAR	34 l/mm low contrast	90 l/mm low contrast
System resolution AWAR		140 l/mm high contrast
Shutter type	Intra-lens	Focal plane
Shutter speeds	1/250 fixed	1/60 to 1/250 variable
Film load	6,000 feet thin base 2 rolls 9-1/2" wide	6,000 feet thin base 2 rolls 9-1/2" wide
Negative orientation	Reversed	Normal
Film direction	Each roll moves opposite direction across platen	Each roll moves in same direction across platen
Film types	SO-1215	SO-243, SO-213, SO-130
IMC	Rocking camera	Rocking of scanning flat
IMC rate	11 milliradians/sec fixed	Up to 25 milliradians/sec
Scan	By rotation of lens barrel	By rotation of scanning flat
Stabilization	Not stabilized	Center-of-gravity gimbal, torquer
Weight w/6000 feet of film	489 pounds	500 pounds, design goal
Size		
Length	54-1/2"	62"
Width	31-3/4"	33"
Height	30-3/16"	49"
Total angular coverage	170 degrees	140 degrees
Useful angular coverage	147 degrees	140 degrees
	77.6 nautical miles	
Mission coverage along flight line	1640 nautical miles	1,925 nautical miles

EFFECT OF SHOCK WAVE

There are several problems in taking pictures from high mach airplanes that are significantly different from sub mach 1 performance. These are:

1. Shock wave refraction.

2. Boundary layer refraction and diffusion.

3. Window heating.

A majority of the reports on these subjects have been written using data taken from wind tunnel tests. It is extremely difficult to obtain accurate data of the type needed because of flow problems, turbulence, boundary layers, etc., across the windows in the tunnel itself. The Boston University Report 128 is an example of this difficulty. The most significant observation of the report is the implied conclusion that either the collimator lens or the tunnel window has limited the system resolution. The report reaches no definite conclusion that the shock wave did deteriorate the imagery. Almost all of the dynamic results came within the 15% deviation found under steady state (no flow) conditions.

Several factors indicate that problems of transmission through the shock wave and boundary layer become easier with increasing speed.

1. The tendency is to operate at higher altitudes where the disturbed air has less optical density.

2. The angle of incidence of the line of sight with respect to the shock wave becomes more favorable at increasing speed.

3. Vehicles designed for high speeds have a more pointed nose and, therefore, produce a weaker shock.

The greatest limitation is at Mach 1 and it is a matter of record that many good photographs have been taken in that region.

The shock front itself is in the order of a few molecular paths thick. It can be thought of as an interface between two layers of air of slightly different optical density. This means that it can be treated as a thin wedge which will cause some deviation of a ray entering it. The most deviation occurs when looking aft because the angle of incidence (see Figure 4) approaches grazing. At 80,000 feet altitude and Mach 3 and

a semicone angle of 10°, the angle of incidence θ_i will be approximately 75° before the deviation is 5 sec of arc. In a camera with a 15° half angle the deviation would not be this large.

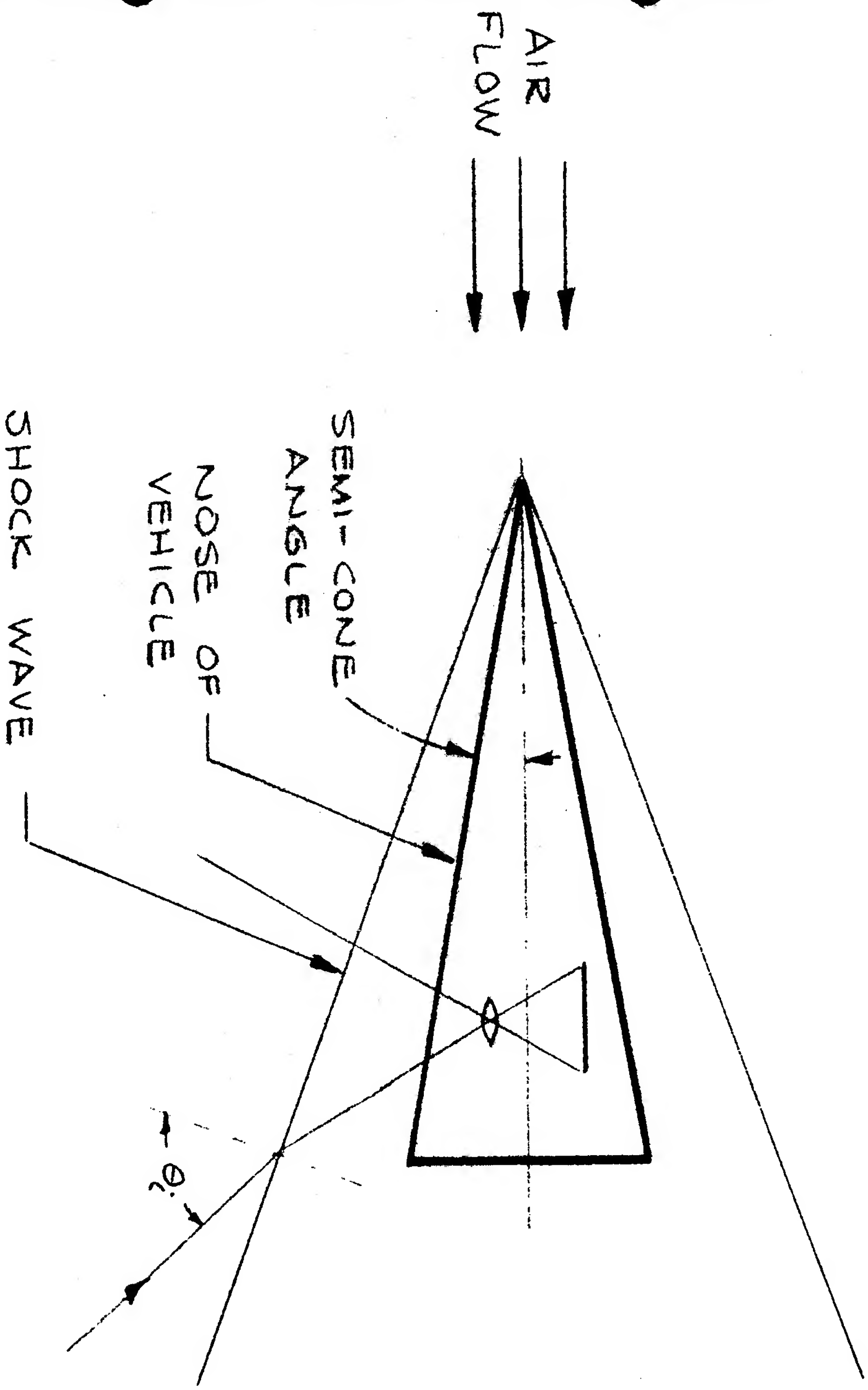
There will be a small defocusing of the image caused by the conical shape of the shock wave. If this proves to be a significant amount, a correction can be built into the camera system to compensate for it. In any case, the amount of defocusing will be a small value.

The boundary layer refraction and diffusion are controllable by various aerodynamic techniques. The design of the window fairing, the location of the camera bay with respect to the nose and the use of bleed air to contract the flow are possible methods.

RESOLUTION

This camera system achieves a ground resolution which is beyond the capability of any presently existing or planned camera. This is achieved through systematic selection of operating parameters. A long focal length is desirable to reduce the requirements for high resolution capability in the lens design to compatability with standard film emulsions not requiring special processing. A 48 inch focal length lens provides the required capability and is, moreover, the longest practicable focal length lens when weight and coverage are considered.

Photo interpreters seeking intelligence information are in general agreement that a six inch ground resolution is a requirement. The HR-244 has, therefore, been designed to provide a ground resolution of <u>6 inches</u> for a low contrast target. When operating altitudes are taken into consideration, this represents a five fold improvement over the resolution provided by the 73B camera.



θ_i = ANGLE OF INCIDENCE BETWEEN LIGHT RAY & SHOCK WAVE

FIG 4

EFFECTS OF WINDOW HEATING

The problem of aerodynamic heating of the camera window has several aspects, including:

1. The mechanical and optical effects of thermal gradients within the window.

2. The effect of radiated heat on camera elements inside the compartment.

3. The additional cooling required for the camera compartment.

Because the ratio of window thickness to width is small (typically about 0.1"), the only important thermal gradient is that between the inner and outer window surfaces. The effects of such a gradient are:

a. To produce a corresponding variation in the index of refraction of the window material, and

b. To induce a slight cupping or bending of the window as a result of greater thermal expansion of the window material near the hotter surface.

To estimate the amount of window cupping, a uniform thermal gradient is assumed, so that the normally planar window assumes a radius of curvature given by the expression:

$$R = \frac{t}{\propto \Delta T},$$

where t is the window thickness
$\propto$ is the coefficient of linear thermal expansion
and ΔT is the temperature differential between the inner and outer surfaces.

For fuzed quartz, $\propto \cong 3 \times 10^{-7}/^{\circ}F$. If t is taken as 1 inch and $\Delta T \approx 700^{\circ}F$, then $R \approx 5000$ inches. Bending of this slight amount would have a negligible optical effect. It may be noted that the bending resulting from heating is in the same direction as that resulting from the air pressure differential; however, the latter effect is likewise of negligible magnitude. Even smaller than the effect of bending would be the effect of temperature variation of the index of refraction of the window material. The windows should, however, be kept small so that lateral temperature variations are minimized.

An analysis of the transmission of heat through a fuzed quartz window is reported in VIDYA Report No. 14, "Effects of Supersonic and Hypersonic Aircraft Speed Upon Aerial Photography". From this work can be drawn the conclusions that only a relatively small increase in air conditioning capacity is required for the camera compartment to carry away the heat entering through the window.

Of greater significance is the effect of radiated heat on the camera mirror and lens. While the mirror, being highly reflective, should absorb little radiated heat, the lens system is more vulnerable. The best solution for this problem appears to be cooling the inside surface of the window; the transmission of infrared radiation by fuzed quartz is poor, so that the amount of radiation from the windows depends largely on the surface temperature. By directing dry cooling air across the interior of the window, a surface temperature near 100°F can be maintained. Although no detrimental effects of significant magnitude are expected from turbulence of the cooling air, turbulence can be minimized by proper design of the air channel in the window region.

Approved For Release 2000/09/07 : CIA-RDP67B00511R000100150005-0

CYCLING RATE

The required cycling rates for three altitudes and three aircraft velocities using 55% forward lap are as follows:

Altitude	Mach 1	Mach 2	Mach 3
80,000	2.0 sec	1.0 sec	0.68 sec
100,000	2.3 sec	1.1 sec	0.83 sec
120,000	2.8 sec	1.4 sec	0.95 sec

There is no question that cycling rates of one second or more are feasible. Considering the 0.95 cycle/sec rate for operation at 120,000 feet and Mach 3 we have to accomplish the following operations in sequence.

1. Move 18-1/2 inches of film over the platen.
2. Apply vacuum.
3. Expose with focal plane shutter.

The breadboard focal plane shutter was operated at curtain speeds 50"/sec for 50,000 cycles after which it was run at a curtain speed of 75 inches/sec for 25,000 cycles. It was then run at speeds up to 100 inches per second. These tests demonstrated that a curtain speed of 100 inches per second with reliable operation is feasible. At 100 inches/sec the cycling time of the shutter is about 0.5 secs. This shutter can, therefore, make the exposure on the 18 x 18 inch format in a little less than two tenths of a second. The vacuum can be applied in about one tenth second as demonstrated by measurement on the 73B system.

For a cycling rate of 0.95 seconds a time of 0.65 seconds is available to move the film which implies a film velocity of about 30 inches/sec. The 73B can cycle film at nearly this rate.

For a cycling rate of 0.83 seconds a time of 0.53 seconds is available to move the film which implies a film velocity of about 35 inches/sec which is considered completely feasible on the basis of experience with the 73B.

For a cycling rate of 0.68 seconds the film velocity would be about 50 inches/sec. This would be the design goal and is considered to be a feasible one though requiring a greater extension in the state of the art than the two cases above.

IMC, through rotation of the mirror, does not present a problem since the mirror can move throughout the entire cycle.

HR-244 ROCKING MIRROR DRIVE

A minimum cycle time (0.68 second) affects three requirements on rocking mirror positioning for lateral scanning.

1. Rapid angular acceleration - 40° in 0.38 second (allowing 0.3 second for stabilization and exposure).

2. Counterbalanced reaction torques - to reduce shock and vibration.

3. Accuracy $\pm 1/4^{\circ}$.

None of these requirements exceeds the state of the art. Compared with a previous application (HR 73C Rocking Mirror Drive), a larger drive motor is required (0.15 HP); a geared counterbalance wheel is necessary (to cancel reaction torque); and a slightly overdamped servosystem is necessary to prevent overshoot time delay without impairing system accuracy. All techniques have been previously employed; only specific mechanism ratings are unique.

Two problems will be encountered in the mechanism design. One is structural rigidity required to prevent spurious modes of vibration (destroying perfect counterbalance) and frictional loads (reducing performance speed). No unusual problems are foreseen in the mechanism size and weight.

This analysis shows that a cycling rate of 0.83 seconds permitting operation at 100,000 feet at a speed of Mach 3 is completely feasible. The extreme case requiring a cycling rate of .68 seconds is possible and would be the design goal.

PHOTO INTERPRETATION EQUIPMENT AND TECHNIQUES

Since the HR-244 camera obtains the same type of coverage as the 73B camera the existing investment in equipment and in trained personnel is protected. Of even greater importance is the fact that these skills are automatically up-graded through provision of higher resolution data. Some of the equipment would have to be up-graded through use of optical attachments to take advantage of the higher resolution photography - however, this expense should be minimal.

LOGISTICS

Since the new system conforms to the logistical requirements of the 73B no new burden is imposed on the present logistical system.

PROCESSING

The film emulsions on which the performance of the HR-244 has been based require no special processing techniques. The presently existing equipment and personnel trained for the 73B system are, therefore, fully capable of handling the HR-244 film. This feature is particularly important in the case of the [redacted]

STATINTL

GROUND SUPPORT EQUIPMENT

The existing ground support equipment provided for the 73B camera will be used for the HR-244 camera. The only requirement foreseen at the present is minor upgrading of some equipment and modification of the camera test set.

For this reason, it is not required to include provision for ground support equipment in this proposal.